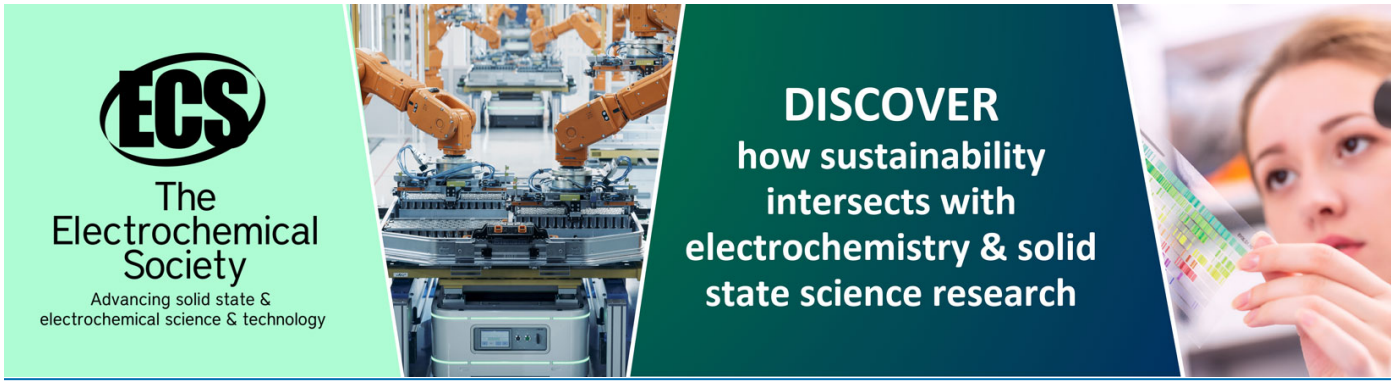
How do we learn about climate sensitivity in the future?



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How do we learn about climate sensitivity in the future?

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One of the difficulties in setting a climatic policy target stems from the uncertainty in climate sensitivity (IPCC, 2007, pp798-799; Roe and Baker, 2007; Tanaka et al., 2008). How the uncertainty in climate sensitivity may change in the future with the acquisition of new observations is an important input to current decision-making on climate policy. To gain insights into this problem, we analyze a historical case – namely, we look into how the estimate of climate sensitivity and its uncertainty change over the historical period 1900-2000. This study uses the inversion setup for the global-annual-mean Aggregated Carbon Cycle, Atmospheric Chemistry, and Climate model (ACC2) (Tanaka and Kriegler et al., 2007; Tanaka, 2008). In our inversion methodology, the best estimates of a number of uncertain parameters are jointly computed by minimizing a cost function consisting of mean square errors of all the parameters and data relative to prior estimates. For this study, we first perform such an inverse calculation only during the period 1750-1900. Then we progressively add new observations and repeat the inverse estimation every five years, analyzing how the best estimate of climate sensitivity and its uncertainty change over time. Our results show that how we learn about climate sensitivity is significantly influenced by how we account for the uncertainty in radiative forcing. In all the results based on different approaches to radiative forcing uncertainty, the evolution of the best estimate of climate sensitivity contains periods of negative learning, unless decadal and multi-decadal variability in the temperature records is accounted for in the learning algorithm. Better prediction skills of the decadal and multi-decadal variability in temperature would allow faster learning on climate sensitivity in the future. Furthermore, even in the absence of long-term temperature variability, the best estimate of climate sensitivity still changes over time, posing a question on the assumption that climate sensitivity is constant in the present day climate system.

References IPCC (2007) Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA. 996 pp. Roe, G. H., M. B. Baker (2007) Why is climate sensitivity so unpredictable? Science, 318, 629-632. Tanaka, K., E. Kriegler, T. Bruckner, G. Hooss, W. Knorr, T. Raddatz (2007) Aggregated Carbon Cycle, Atmospheric Chemistry, and Climate Model (ACC2): description of the forward and inverse modes. Reports on Earth System Science No. 40. Max Planck Institute for Meteorology, Hamburg. 188 pp. http://www.mpimet.mpg.de/wissenschaft/publikationen/erdsystemforschung.html Tanaka, K. (2008) Inverse estimation for the simple Earth system model ACC2 and its applications. Ph.D. dissertation. Hamburg Universität. International Max Planck Research School on Earth System Modelling, Hamburg. 296 pp. http://www.sub.uni-hamburg.de/opus/volltexte/2008/3654/ Tanaka, K., T. Raddatz, B. C. O'Neill, C. Reick (2008) Is the Climate Sensitivity Even More Uncertain? Interim Report at International Institute for Applied Systems Analysis (IIASA) IR-08-012. 79 pp. Submitted to Proceedings of the National Academy of Sciences (PNAS), USA. http://www.iiasa.ac.at/Admin/PUB/Documents/IR-08-012.pdf

